PROBLEMS

1. (a) $\dfrac{12.15\text{ g}}{12.15\text{ g} + 175\text{ g}} \times 100\% = 6.49\%$

   (b) mol $Ni(NO_3)_2 = \dfrac{12.15\text{ g}}{182.7\text{ g/mol}} = 0.06650$; mol $H_2O = \dfrac{175\text{ g}}{18.02\text{ g/mol}} = 9.71$

   mol Ni^{2+} = mol $Ni(NO_3)_2$ = 0.06650; mol NO_3^- = 2(mol $Ni(NO_3)_2$) = 0.1333

   $$X_{Ni(NO_3)_2} = \frac{0.06650}{0.06650 + 0.1333 + 9.71} = 0.00671$$

3. Assume 100.0 g of vinegar (solution); 5.00% $HC_2H_3O_2$ = 5.00 g $HC_2H_3O_2$ in solution

   mol $HC_2H_3O_2 = \dfrac{5.00\text{ g}}{60.05\text{ g/mol}} = 0.0833$; $V_{sol'n} = \dfrac{100.0\text{ g}}{1.006\text{ g/mL}} = 99.4$ mL

   M = 0.0833 mol/0.0994 L = 0.838 M

5. (a) 8 glasses of $H_2O \times \dfrac{8\text{ oz}}{1\text{ glass}} \times \dfrac{1\text{ lb}}{16\text{ oz}} \times \dfrac{453.6\text{ g}}{1\text{ lb}} \times \dfrac{0.028\text{ g Ag}^+}{10^6\text{ g H}_2\text{O}} \times \dfrac{1000\text{ mg}}{1\text{ g}} = 0.051$ mg

   (b) $1.00\text{ g Ag} \times \dfrac{10^6\text{ g H}_2\text{O}}{0.028\text{ g Ag}} \times \dfrac{1\text{ L H}_2\text{O}}{1000\text{ g H}_2\text{O}} = 3.6 \times 10^4\text{ L}$

7. Molar mass of $CuSO_4$ = 159.62 g/mol

   (a) $M = \dfrac{(12.50/159.62)\text{ mol}}{0.478\text{ L}} = 0.164$ mol/L

   (b) mass = (0.299 mol/L)(0.283 L)(159.62 g/mol) = 13.5 g

   (c) $V = \dfrac{(4.163\text{ g})(1\text{ mol}/159.62\text{ g})}{0.8415\text{ mol/L}} = 0.03099\text{ L} = 30.99\text{ mL}$

9. Molar mass of caffeine = 194.2 g/mol

   (a) Assume 1.000 mole of solution. Thus solution has 0.900 mol H_2O, and 0.100 mol caffeine

   mass H_2O = 0.900 mol(18.02 g/mol) = 16.2 g; mass caffeine = 0.100 mol(194.2 g/mol) = 19.4 g

   $m = \dfrac{0.100\text{ mol}}{0.0162\text{ kg}} = 6.17$ mass % $= \dfrac{16.2\text{ g}}{(16.2 + 19.4)\text{ g}} \times 100 = 45.5\%$

   ppm solute $= \dfrac{16.2\text{ g}}{(16.2 + 19.4)\text{ g}} \times 10^6 = 4.55 \times 10^5$

(b) Assume 1.000×10^6 g of solution. Thus solution has 9.987×10^5 g H_2O, and 1269 g caffeine.

mol $H_2O = \dfrac{9.987 \times 10^5\ \text{g}}{18.02\ \text{g/mol}} = 5.542 \times 10^4$; mol caffeine $= \dfrac{1269\ \text{g}}{194.2\ \text{g/mol}} = 6.535$

$m = \dfrac{6.535\ \text{mol}}{998.7\ \text{kg}} = 6.543 \times 10^{-3}$ mass % $= \dfrac{9.987 \times 10^5\ \text{g}}{10^6\ \text{g}} \times 100 = 99.87\%$

$X_{H_2O} = \dfrac{5.542 \times 10^4\ \text{mol}}{(5.542 \times 10^4 + 6.535)\ \text{mol}} = 0.9999$

(c) Assume 100.0 g of solution. Thus solution has 85.5 g H_2O, and 14.5 g caffeine.

mol $H_2O = \dfrac{85.5\ \text{g}}{18.02\ \text{g/mol}} = 4.74$; mol caffeine $= \dfrac{14.5\ \text{g}}{194.2\ \text{g/mol}} = 0.0747$

$m = \dfrac{0.047\ \text{mol}}{0.0855\ \text{kg}} = 0.873$ ppm $= \dfrac{14.5\ \text{g}}{100.0\ \text{g}} \times 10^6 = 1.45 \times 10^5$

$X_{H_2O} = \dfrac{4.74\ \text{mol}}{(4.74 + 0.0747)\ \text{mol}} = 0.984$

(d) Assume 1000.00 g of solvent (H_2O). Thus solution has 0.2560 mol caffeine.

mol $H_2O = \dfrac{1000.00\ \text{g}}{18.02\ \text{g/mol}} = 55.49$; mass caffeine = (0.2560 mol)(194.2 g/mol) = 49.72 g

mass % $= \dfrac{1000.00\ \text{g}}{(1000.00 + 49.72)\ \text{g}} \times 100 = 95.26\%$ ppm $= \dfrac{49.72\ \text{g}}{(1000.00 + 49.72)\ \text{g}} \times 10^6 = 4.737 \times 10^4$

$X_{H_2O} = \dfrac{55.49\ \text{mol}}{(55.49 + 0.2560)\ \text{mol}} = 0.9954$

11. (a) MM $K_2Cr_2O_7$ = 294.20 g/mol; Mass $K_2Cr_2O_7$ needed = (0.465 L)(0.3550 mol/L)(294.2 g/mol) = 48.6 g

Weigh out 48.6 g, dissolve in enough water to form 465 mL of solution.

(b) V(0.750) = (0.465)(0.3550); V = 0.220 L; Dilute 0.220 L of 0.750 M $K_2Cr_2O_7$ to 0.465 L.

13. (a) mol $Al_2(SO_4)_3 = 0.225\ \text{L} \times 0.1885\ \text{mol/L} = 0.0424$

(b) $M_{Al_2(SO_4)_3} = 0.0424\ \text{mol}/1.450\ \text{L} = 0.0292\ \text{mol/L}$

$M_{Al^{3+}} = 2(M_{Al_2(SO_4)_3}) = 2(0.0292\ M) = 0.0584\ M$; $M_{SO_4^{2-}} = 3(M_{Al_2(SO_4)_3}) = 3(0.0292\ M) = 0.0876\ M$

15. Consider one liter of solution weighing 1689 g.

mass H_3PO_4 = (0.850)(1689 g) = 1436 g; mass H_2O = 1689 − 1436 = 253 g

$M_{H_3PO_4} = \dfrac{1436\ \text{g}}{1.00\ \text{L}} \times \dfrac{1\ \text{mol}}{97.99\ \text{g}} = 14.7\ \text{mol/L}$; $m_{H_3PO_4} = (14.7\ \text{mol})/(0.253\ \text{kg } H_2O) = 57.9$

$X_{H_3PO_4} = \dfrac{14.7}{14.7 + 14.0} = 0.511$

17. MM_{KOH} = 56.11 g/mol

(a) Assume one liter of solution; mass of solution = 1.050 g/mL × 1000 ml = 1050 g

KOH: n = 1.13 mol; mass = 1.13 mol × 56.11 g/mol = 63.4 g

H_2O: mass = 1050 g − 63.4 g = 987 g

m = 1.13 mol/0.987 kg = 1.14 % KOH = (63.4 g/1050 g) × 100 = 6.04%

(b) Assume one hundred grams of solution; volume of solution = $\frac{100.0\text{ g}}{1.29\text{ g/mL}}$ = 77.5 mL

KOH: mass = 30.0 g; $n = \frac{30.0\text{ g}}{56.11\text{ g/mol}}$ = 0.535 mol

H_2O: mass = 100.0 g − 30.0 g = 70.0 g

m = 0.535 mol/0.070 kg = 7.64 M = 0.535 mol/0.0775 L = 6.90 mol/L

(c) Assume one thousand grams of solvent (H_2O)

KOH: n = 14.2 mol; mass = (14.2 mol)(56.11 g/mol) = 797 g

solution: mass = 1000.0 + 797 = 1797 g ; volume = $\frac{1797\text{ g}}{1.43\text{ g/mL}}$ = 1257 mL

M = 14.2 mol/1.257 L = 11.3 mol/L % KOH = (797 g/1797 g) × 100 = 44.4%

19. Assume that the sucrose amount in 30 L of maple sap is negligible.

30 L sap ≈ 30 L H_2O ≈ 30 kg H_2O

(1/4)(30) = 7.5 kg; mass of H_2O ≈ 22.5 kg

In syrup: 1 kg syrup × 66% sucrose = 660 g; mol sucrose = $\frac{660\text{ g}}{342\text{ g/mol}}$ = 1.93

m = 1.93 mol/22.5 kg = 0.086

21. (a) CCl_4; it is nonpolar like benzene

(b) C_6H_{14}; it is nonpolar like benzene

(c) heptanoic acid; dispersion forces similar to those of benzene

(d) propyl chloride; dispersion forces similar to those of benzene

23. (a) H_2O_2; hydrogen bonding

(b) NaOH; ionic versus network covalent

(c) HCl; ionic vs molecular

(d) CH_3OH; hydrogen bonding

25. (a) $\Delta H = \Delta H_f^\circ\, Pb^{2+}(aq) + 2\,\Delta H_f^\circ\, Cl^-(aq) - \Delta H_f^\circ\, PbCl_2(s)$ = (− 1.7 − 334.3 + 359.4) kJ = +23.3 kJ

(b) yes; solution process is endothermic

27. (a) $k = 3.8 \times 10^{-4} \dfrac{M}{\text{atm}} \times \dfrac{1\text{ atm}}{760\text{ mm Hg}} = 5.0 \times 10^{-7}\ M/\text{mm Hg}$

(b) $C = 5.0 \times 10^{-7} \dfrac{M}{\text{mm Hg}} \times 293\text{ mm Hg} = 1.5 \times 10^{-4}\ M$

(c) mol He = $(1.5 \times 10^{-4}\text{ mol/L})(10.00\text{ L}) = 1.5 \times 10^{-3}$

$$V = \frac{(1.5 \times 10^{-3}\text{ mol})(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(298\text{ K})}{(293/760\text{ atm})} = 0.095\text{ L} = 95\text{ mL}$$

29. (a) $C = (0.0769\ M/\text{atm})(3.0\text{ atm}) = 0.23\ M$

(b) $C = (0.0313\ M/\text{atm})(3.4 \times 10^{-4}\text{ atm}) = 1.1 \times 10^{-5}\ M$

31. Assume one hundred mL of vodka. Mass of vodka = 100.0 g. Volume C_2H_5OH in vodka = 40.0 mL

C_2H_5OH: mass = 40.0 mL × 0.789 g/mL = 31.56 g; $n = \dfrac{31.56\text{ g}}{46.07\text{ g/mol}} = 0.685\text{ mol}$

H_2O: mass = 100.0 - 31.56 = 68.4 g = 0.0684 kg

m = 0.685 mol/0.0684 kg = 10.0

$\Delta T_f = 1.86 \dfrac{m}{°\text{C}} \times 10.0\ m = 18.6°\text{C}$; $T_f = -18.6°\text{C}$

33. (a) $X_{H_2O} = 1.000 - 0.288 = 0.712$; $P_{H_2O} = (19.83\text{ mm Hg})(0.712) = 14.1\text{ mm Hg}$

(b) Assume one hundred g of solution; mass H_2O = 100.0 − 39.0 = 61.0 g

$X_{H_2O} = \dfrac{(61.0/18.02)\text{ mol}}{(61.0/18.02)\text{ mol} + (39.0/62.07)\text{ mol}} = 0.843$; $P = 0.843 \times 19.83\text{ mm Hg} = 16.7\text{ mm Hg}$

(c) Assume one hundred g of solution; mass H_2O = 100.0 − 39.0 = 61.0 g

$X_{H_2O} = \dfrac{(1000.0/18.02)\text{ mol}}{(1000.0/18.02)\text{ mol} + 2.42\text{ mol}} = 0.9582$; $P = 0.9582 \times 19.83\text{ mm Hg} = 19.00\text{ mm Hg}$

35. $X_{CCl_4} = P_1/P° = 483\text{ mm Hg}/504\text{ mm Hg} = 0.042$; mol $CCl_4 = \dfrac{25.00\text{ g}}{153.8\text{ g/mol}} = 0.163$

$X_{CCl_4} = \dfrac{\text{mol } CCl_4}{\text{mol } CCl_4 + \text{mol } C_{10}H_8}$; $0.042 = \dfrac{0.163}{0.163 + \text{mol } C_{10}H_8}$; mol $C_{10}H_8$ = 0.00715

mass $C_{10}H_8$ = 0.00715 mol × 128.2 g/mol = 0.92 g

37. (a) $\Pi = (0.217\text{ mol/L})(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(295\text{ K}) = 5.26\text{ atm}$

(b) $M = \dfrac{(25.0/60.06)\text{ mol}}{0.685\text{ L}} = 0.608\text{ mol/L}$

$\Pi = (0.608\text{ mol/L})(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(295\text{ K}) = 14.7\text{ atm}$

(c) Assume one liter of solution; mass of solution = 1000.0 mL $\times$ 1.12 g/mL = 1120 g

mol urea = $\frac{(1120 \times 0.150)\text{ g}}{60.06\text{ g/mol}}$ = 2.80; Π = (2.80 mol/L)(0.0821 L · atm/mol · K)(295 K) = 67.8 atm

39. (a) Assume one hundred grams of solution

mass glycerine = 25.0 g; mass H_2O = 100.0 – 25.0 = 75.0 g = 0.075 kg

mol glycerine = $\frac{25.0\text{ g}}{92.1\text{ g/mol}}$ = 0.272; m = 0.272 mol/0.0750 kg = 3.62

ΔT_f = 3.62 m (1.86 °C/m) = 6.73°C; T_f = –6.73°C

ΔT_b = 3.62 m (0.52 °C/m) = 1.9°C; T_b = 101.9°C

(b) mol $C_3H_8O_2$ = $\frac{28.0\text{ g}}{76.1\text{ g/mol}}$ = 0.368; m = 0.368 mol/0.325 kg = 1.13

ΔT_f = 1.13 m (1.86 °C/m) = 2.10°C; T_f = –2.10°C

ΔT_b = 1.13 m (0.52 °C/m) = 0.59°C; T_b = 100.59°C

(c) mass C_2H_5OH = (25.0 mL)(0.780 g/mL) = 19.5 g; mol C_2H_5OH = $\frac{19.5\text{ g}}{46.07\text{ g/mol}}$ = 0.423

m = 0.423 mol/0.735 kg = 0.576

ΔT_f = 0.576 m (1.86 °C/m) = 1.07°C; T_f = –1.07°C

ΔT_b = 0.576 m (0.52 °C/m) = 0.30°C; T_b = 100.30°C

41. mass acetone = (39 mL)(0.790 g/mL) = 31 g; mol acetone = $\frac{31\text{ g}}{58.1\text{ g/mol}}$ = 0.53

m = 0.53 mol/0.225 kg = 2.36

ΔT_f = 2.36 m (1.86 °C/m) = 4.4°C; T_f = –4.4°C

ΔT_b = 2.36 m (0.52 °C/m) = 1.2°C; T_b = 101.2°C

43. mol lactic acid = $\frac{13.66\text{ g}}{90.1\text{ g/mol}}$ = 0.152; m = 0.152 mol/0.115 kg stearic acid = 1.32

$$k_f = \frac{\Delta T_f}{m} = \frac{(69.4 - 62.7)°\text{C}}{1.32\ m} = 5.1\ °\text{C}/m$$

45. $M = \frac{\Pi}{RT} = \frac{(2.5/760)\text{ atm}}{0.0821\text{ L} \cdot \text{atm/mol} \cdot \text{K} \times 298\text{ K}} = 1.34 \times 10^{-4}$ mol/L

n = (1.34 × 10^{-4} mol/L)(0.125 L) = 1.68 × 10^{-5} mol; MM = 0.100 g/1.68 × 10^{-5} mol = 6.0 × 10^3 g/mol

47. $m = \frac{\Delta T_b}{k_b} = \frac{(80.78 - 80.10)°C}{2.53\,°C/m} = 0.27$; n = (0.27 mol/kg)(0.100 kg) = 0.027 mol

MM = 5.00 g/0.027 mol; formula mass = molar mass; Molecular formula is $C_{12}H_{26}O$

49. Simplest formula: Assume one hundred grams of compound.

mol C = $\frac{49.5\text{ g}}{12.0\text{ g/mol}}$ = 4.125; mol H = $\frac{5.2\text{ g}}{1.008\text{ g/mol}}$ = 5.16

mol O = $\frac{16.5\text{ g}}{16.00\text{ g/mol}}$ = 1.031; mol N = $\frac{18.9\text{ g}}{14.01\text{ g/mol}}$ = 2.061

Ratios of atoms: 2 N : 4 C : 5 H : 1 O; Simplest formula is $C_4H_5N_2O$; formula mass = 97 g/mol

Molecular formula:

mass solvent = (100.0 mL)(0.877 g/mL) = 87.7 g = 0.0877 kg

$m = \frac{\Delta T_f}{k_f} = \frac{(5.50 - 3.03)°C}{5.10\,°C/m} = 0.484$; mol solute = 0.484 mol/kg × 0.0877 kg = 0.0424

MM = 8.25 g/0.0424 mol = 194.4 g/mol; 194/97 = 2; MM = 2(formula mass)

Molecular formula is $C_8H_{10}N_4O_2$

51. $M = \frac{\Pi}{RT} = \frac{(4.18/760)\text{ atm}}{(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(298\text{ K})} = 2.25 \times 10^{-4}$ mol/L

$n = (2.25 \times 10^{-4}\text{ mol/L})(0.0500\text{ L}) = 1.12 \times 10^{-5}$ mol;

MM = $\frac{0.225\text{ g}}{1.12 \times 10^{-5}\text{ mol}} = 2.00 \times 10^4$ g/mol

53. (a) ΔT_f = 2(0.25)(1.86°C) = 0.93°C; T_f = −0.93°C

ΔT_b = 2(0.25)(0.52°C) = 0.26°C; T_b = 100.26°C

(b) ΔT_f = 1.9°C; T_f = −1.9°C; T_b = 100.52°C

(c) ΔT_f = 5(0.25)(1.86°C) = 2.3°C; T_f = −2.3°C

ΔT_b = 5(0.25)(0.52°C) = 0.65°C; T_b = 100.65°C

55. $\frac{\Pi}{iRT} = \frac{7.7\text{ atm}}{(2)(0.0821\text{ L}\cdot\text{atm/mol}\cdot\text{K})(298\text{ K})}$ = 0.16 mol/L

57. (a) $i = \frac{\Delta T_f}{m\,k_f} = \frac{0.38°C}{(0.20\,m)(1.86°C/m)}$ = 1.0

(b) (iii)

59. $m = \dfrac{\Delta T_f}{i\,k_f} = \dfrac{1.81°C}{(2)(1.86°C/m)}$ = 0.487 mol/kg; mol LiX = (0.487 mol/kg)(0.283 kg) = 0.138

MM of LiX = 3.58 g/0.138 mol = 26.0 g/mol; MM of X^- = 26.0 – MM of Li^+ = 26.0 – 6.94 = 19.1 g/mol

X^- is F^-

61. Assume one thousand mL (one L) of solution. mass of solution = (1000.0 ml)(1.203 g/mL) = 1203 g

(a) mass sucrose = 1203 × 0.450 = 541 g; mol sucrose = $\dfrac{541\text{ g}}{343.2\text{ g/mol}}$ = 1.58

M = 1.58 mol/1 L sol'n = 1.58 mol/L

(b) mass H_2O = 1203 – 541 = 662 g = 0.662 kg; m = 1.58 mol/0.662 kg = 2.39

(c) $X_{H_2O} = \dfrac{(662/18.02)\text{ mol}}{(662/18.02)\text{ mol} + 1.58\text{ mol}}$ = 0.959 $P = X_{H_2O}P°$ = 0.959(23.76 mm Hg) = 22.8 mm Hg

(d) $\Delta T_b = k_f\,m$ = (0.52°C/m)(2.39 m) = 1.2°C; T_b = 101.2°C

63. mass solution = (2.50 × 10^4 mL)(1.08 g/mL) = 2.70 × 10^4 g

mass $KMnO_4$ = (0.150)(2.70 × 10^4 g) = 4.05 × 10^3 g;

Weigh 4.05 × 10^3 g $KMnO_4$ and dilute with water to 25.0 L

mol $KMnO_4$ = $\dfrac{4.05 \times 10^3\text{ g}}{158.0\text{ g/mol}}$ = 25.6; M = 25.6 mol/25.0 L = 1.02 mol/L

65. (a) $BaSO_4$

(b) $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

mass solution = (25.00 mL)(1.107 g/mL) = 27.68 g; mass H_2SO_4 = (27.68 g)(0.1525) = 4.220 g

mol H_2SO_4 = mol SO_4^{2-} = $\dfrac{4.220\text{ g}}{98.0\text{ g/mol}}$ = 0.04303;

mol $BaCl_2$ = mol Ba^{2+} = (2.45 mol/L)(0.050 L) = 0.122

SO_4^{2-} is limiting; 0.0430 mol $BaSO_4$ is obtained

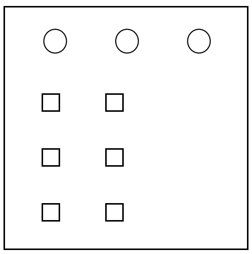
mass $BaSO_4$ = (0.04303 mol)(233.4 g/mol) = 10.04g

(c) mol Cl^- = 2(mol $BaCl_2$) = 2(0.122) = 0.244; $M_{Cl^-} = \dfrac{0.244\text{ mol}}{(0.050 + 0.025)\text{ L}}$ = 3.25 mol/L

67. $m = \frac{\Delta T_b}{k_b} = \frac{(81.20 - 80.10)°C}{2.53°C/m} = 0.435$; 0.435 mol $C_{10}H_8$/ thousand g of benzene

mass $C_{10}H_8$ = (0.435 mol)(128 g/mol) = 55.8 g; % benzene = $\frac{1000.0 \text{ g}}{(1000.0 + 55.8) \text{ g}} \times 100 = 94.7\%$

69. Presumably, solution inside the cell is more dilute than that outside. Water moves out of the cell by osmosis. The cell shrinks.

71.  6 M in Na^+; 3 M in S^{2-}

73. 1 ppb = $\frac{1 \text{ g}}{10^9 \text{ g}} \times \frac{10^6\ \mu\text{g}}{1 \text{ g}} \times \frac{10^3 \text{ g}}{1 \text{ kg}} = \frac{1\ \mu\text{g}}{1 \text{ kg}}$

75. (a) greater (b) less than (c) greater (d) less than

77. (a) more ions in $CaCl_2$

(b) formation of solution usually absorbs heat to break down the crystal lattice

(c) If $P > \Pi$, water moves in reverse direction.

(d) i = 3 as opposed to i = 1

(e) One liter of solution contains approximately one kilogram of water.

79. (a) Ions present lower the freezing point.

(b) Sugar crystallizes out on cooling.

(c) If Π of solution = Π of blood, or water will move one way or another.

(d) more O_2 present

(e) When pressure is released, bubbles of CO_2 come out of solution.

81. (a) < (b) < (c) > (d) > (e) =

82. $m = \frac{\Delta T_b}{i\,k_b} = \frac{3.0°C}{(2)(0.52°C/m)} = 2.9$; $M = \frac{\Pi}{i\,RT} = \frac{122 \text{ atm}}{(2)(0.0821 \text{ L}\cdot\text{atm/mol}\cdot\text{K})(298 \text{ K})} = 2.49$

Assume one thousand g of solvent; solution has 2.9 moles KNO_3 = 291 g.

mass solution = (1000 + 291) g = 1291 g

M = mol solute/$V_{sol'n}$; 2.49 = 2.9/V; V = 1.16 L = 1160 mL

density = mass/volume = 1291 g/1160 mL = 1.1 g/mL

83. mol KOH = 158.2 g $\times \frac{1 \text{ mol}}{56.11 \text{ g}}$ = 2.819 in one liter, 0.2819 mol in 100 mL.

mass water = 0.2819/0.250 = 1.128 kg = 1128 g

mass water available = 113 g − 15.82 g = 97 g; add 1.03×10^3 g of water

84. Assume one thousand mL of solution.

moles solute = molarity (M); mass solute = $M \times$ MM; mass solution = 1000 $\times d$

$$\text{mass } H_2O \text{ (in kg)} = \frac{\text{mass solution} - \text{mass solute}}{1000} = \frac{1000d - M\,\text{MM}}{1000}$$

$$\text{molality } (m) = \frac{\text{moles solute}}{\text{mass } H_2O \text{ (kg)}} = \frac{M}{d - \frac{M \times \text{MM}}{1000}}$$

85. Let x = mass of X; moles X = $x/410$; moles sugar = $(0.100 - x)/342$

$\frac{(x/410) + [(0.100 - x)/342]}{0.00100}$; x = 0.049 g; 49% X

86. $\frac{142 \text{ g} \times 0.300 \times 0.15 \times 2}{7.0 \times 10^3 \text{ cm}^3} = 0.0018 \text{ g/cm}^3$

87. (a) $M_{NaOH} = \frac{49.92 \text{ g}}{0.600 \text{ L}} \times \frac{1 \text{ mol}}{40.00 \text{ g}} = 2.08 \text{ mol/L}$

(b) If NaOH is limiting: 1.248 mol NaOH yields 1.872 mol H_2

If Al is limiting: 1.530 mol Al yields 2.295 mol H_2

Yield of H_2 must be 1.872 mol

(c) $V = \frac{(1.872 \text{ mol})(0.0821 \text{ L}\cdot\text{atm/mol}\cdot\text{K})(298 \text{ K})}{(734.8/760) \text{ atm}} = 47.4 \text{ L}$

88. $V = nRT/P$ (ideal gas law)

n/P = constant (Henry's law)

V = constant $\times$ RT; V must be constant at constant temperature